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Exposure to environmental tobacco smoke in Finland in 2000

by Timo P Kauppinen, PhD,[1] Simo V Virtanen, PhD[1]

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Objectives Exposure to environmental tobacco smoke at workplaces, homes and other places was assessed.
Methods Exposure to environmental tobacco smoke was defined as occurring when a person reported inhaling, at least occasionally, tobacco smoke from other people's smoke. Some of the exposed were also smokers themselves. Questionnaire-based survey data and industrial hygiene measurements on environmental tobacco smoke were used to estimate the numbers of exposed persons by exposure level in Finland in January 2000.
Results About 340 000 workers (16% of the employed population) were exposed to environmental tobacco smoke at work, of them 30 000 were exposed almost continuously (1.4% of the employed population). The mean level of exposure was 1 μg/m³ as measured by nicotine in workroom air. The nicotine concentration ranged from <1 to >100 μg/m³. Nearly 600 000 Finns (11% of the population) were exposed to environmental tobacco smoke at home. According measurements abroad, their mean nicotine exposure corresponded to about 4 μg/m³ at work. In addition, over 1 million Finns were exposed during leisure time to an unknown mean level of environmental tobacco smoke. Annual exposure of the Finnish population in January 2000 was estimated to originate mainly from smoking at home (48%) and leisure time in smoky restaurants (45%). Smoking was restricted at workplaces in 1995 and occupational exposure constituted 7% of the total population exposure in January 2000. New restrictions on smoking in restaurants should decrease the exposure of restaurant workers and customers even further.
Conclusions In spite of regulations, environmental tobacco smoke still remains the most common occupational exposure to chemical carcinogens in Finland.

Key terms environmental tobacco smoke, home, occupational exposure, restaurants, risk assessment.

Finland restricted smoking at work in 1995 by passing the Tobacco Control Act, according to which indoor smoking at workplaces is prohibited except in smoking rooms isolated from other premises. Occupational exposure to environmental tobacco smoke decreased substantially in many workplaces but continued in restaurants because the smoking of customers was unregulated. In the interest of brevity we often use the word "restaurant" when referring to any "eating and drinking place", including food restaurants, bars and clubs. An amendment to the Tobacco Control Act restricted smoking of customers by requiring that 30% of customer seats be smokeless from March 2000 on. As of July 2001 this restriction applied to 50% of customer seats. Because smoking in restaurants is not entirely prohibited, a question rose about the criterion of smokelessness and the possible need for an exposure limit in smoky premises. The Finnish Ministry of Social Affairs and Health asked the Scientific Committee on Health Effects of Chemicals to evaluate the health risks of environmental tobacco smoke in the current exposure situation. The exposure assessment in our paper was prepared in this context to support the quantification of risks due to environmental tobacco smoke.

Material and methods

Numbers exposed at work

We defined exposure to environmental tobacco smoke as occurring when a person reported having inhaled, at least occasionally, tobacco smoke originating from the smoking of other people. This definition was independent

1 Finnish Institute of Occupational Health, Department of Epidemiology and Biostatistics, Helsinki, Finland.

Reprint requests to: Dr Timo Kauppinen, Finnish Institute of Occupational Health, Department of Epidemiology and Biostatistics, Topeliuksenkatu 41aA, FIN-00250 Helsinki, Finland. [E-mail: tkau@occuphealth.fi]

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of a person's own smoking. Therefore, some of the exposed persons were also smokers themselves. On the other hand, all smokers are not exposed to environmental tobacco smoke. This is the case when a smoker inhales only the smoke from his or her own smoking. The rationale for also counting smokers exposed to environmental tobacco smoke was that the additional dose due to environmental tobacco smoke was considered to add to the risk of contracting lung cancer and other tobacco-related diseases among both nonsmokers and smokers.

Three major sources provide information on exposure to environmental tobacco smoke at work in Finland. Statistics Finland carried out in-person surveys on work conditions in 1977, 1984, 1990, and 1997. The National Public Health Institute has studied the health behavior of the Finnish adult population through the aid of postal surveys annually since 1985. The Finnish Institute of Occupational Health carried out telephone interviews with a sample of Finns of workage in 1997 and 2000.

The Statistics Finland survey included a question on environmental tobacco smoke in 1990 and 1997. The sample comprised 5000 employed persons, including 3502 salaried workers, in 1990. In 1997, the sample included 3800 salaried workers, of whom 2979 could be interviewed (1). The question on environmental tobacco smoke was as follows: "In your work environment, how prevalent is tobacco smoke due to the smoking of others ('passive smoking')?" One of the following alternatives could be selected by the respondents: almost all the time, about three-fourths of the time, half of the time, about one-fourth of the time, less often, never. We used the responses to this question to help calculate the numbers of exposed workers. We included everyone in the exposed group except those who responded "never". Gender, age group, industry (Standard Industrial Classification of Finland from 1995, harmonized with NACE Rev1 of the European Union), occupation (Standard Occupational Classification of Finland from 1987), and size of workplace were included as variables in the statistical analyses of data on environmental tobacco smoke carried out by us at the Finnish Institute of Occupational Health.

The sample in the survey on health behavior by the National Public Health Institute included about 5000 Finns between 15 and 64 years of age. The response rate to this postal questionnaire is around 70%, resulting annually in about 3500 respondents, including 2100 employed, 300 unemployed, and 1100 persons from outside the workforce (students, homemakers, retired, etc) (2). The question on environmental tobacco smoke has been "How many hours daily are you at your workplace in rooms and other premises whose air contains tobacco smoke?" This formulation of the question on environmental tobacco smoke is not in accordance with our definition because it does not exclude cases in which a person is exposed to self-generated tobacco smoke only (eg, smoking alone in own workroom or smoking alone outdoors).

The survey of the Finnish Institute of Occupational Health used computer-assisted telephone interviews of Finns aged 25–64 years in 1997 and 2000. The sample in 1997 was 4544 persons, of whom 3202 (70%) could be traced and interviewed. In the spring of 2000, 2900 (58%) of 4979 persons were interviewed (3). The numbers of employed interviewed were 2156 in 1997 and 2053 in 2000. The question on environmental tobacco smoke was "Is there, in your work, tobacco smoke due to smoking of others?" The response alternatives were no, yes but it doesn't bother, it bothers to some extent, it bothers quite a lot, it bothers very much. This question corresponds to our definition of exposure to environmental tobacco smoke. The prevalence figures are also well in keeping with the Statistics Finland survey: 14% of the employed persons in both surveys reported exposure in 1997. The advantage of the survey of the Finnish Institute of Occupational Health is that it provides the newest information (prevalence of exposure among employed persons being 12% in 2000). Its response alternatives are expressions of perceived ("subjective") harm due to exposure, and therefore they do not allow the calculation of average exposure levels of exposed workers. The survey of Statisitics Finland addresses ("objective") duration of exposure, which can be directly used to estimate the average exposure during the workyear when the level during exposure is known from industrial hygiene measurements.

On the basis of these considerations, we selected the results of the Statistics Finland 1997 survey as the basis of our estimates on the number of workers exposed to environmental tobacco smoke in January 2000. Because this survey did not cover self-employed persons (eg, farmers, entrepreneurs, 15% of the employed population), this estimate for 1997 was probably lower than the true number of exposed workers. However, according to the survey of the Finnish Institute of Occupational Health the prevalence of exposure to environmental tobacco smoke between 1997 and the spring of 2000 had also decreased from 14% to 12% (ie, by about 15%), the finding suggesting that the estimates of the numbers of exposed persons from the Statistics Finland 1997 survey are probably valid for the total employed workforce in January 2000.

Exposure levels at work

Only one of the available risk models for environmental tobacco smoke is specific in relation to occupational exposure. The model by Repace et al (4) states that 45 years of occupational exposure to an average nicotine

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concentration of 6.7 μg/m³ from environmental tobacco smoke causes one case of lung cancer among 1000 exposed workers. This result guided us to use the concentration of nicotine as a quantitative marker of exposure. Nicotine is also the most commonly used marker of environmental tobacco smoke in occupational hygiene measurements.

Two Finnish studies measured nicotine levels in restaurants in 1999 (5 and Johnsson et al, unpublished). In addition, one study of selected industrial and service workplaces reported nicotine levels before the prohibition of smoking at workplaces except in isolated smoking rooms in 1995 (6).

The first study included restaurants and other similar places where ventilation was considered to be representative of current conditions (5). The area of restaurants ranged from 80 to 530 cubic meters and the ventilation changed the air of the restaurant from 4 to 13 times per hour. Air samples were drawn into absorption bottles from static sampling points in the work area during about 4 hours on two to four evenings. Nicotine was analyzed from samples by gas chromatography.

The second study in restaurants (Johnsson et al, unpublished) measured nicotine at static points (3–5/restaurant) and from the breathing zone of workers. The samples were collected into adsorption tubes and analyzed by gas chromatography-mass spectrometry after thermal desorption. The sampling time was approximately 4 hours, and the measurements were done twice in every restaurant.

The study in industrial and service sectors concerned medium-sized and large companies (6). Smoking was allowed at least in designated areas of these workplaces during the measurements. Air samples were collected from four to seven static points during a workday between November and January. The sampling points were usually in corridors, coffee rooms, and workrooms close to the smoking area.

Exposure at home

The annual questionnaire survey on the health behavior of adults (15–64 years) by the National Public Health Institute includes a question on exposure to tobacco smoke at home (2). The question is "Do you smoke or does another person of your family smoke in your dwelling?" The respondents are asked to tick one or more of the options "myself", "my spouse", "somebody else". The survey report includes data on the overall prevalence of tobacco smoke at home. The National Public Health Institute provided us with data on cases in which only the respondent reported of having smoked at home. We estimated the prevalence of exposure to environmental tobacco smoke by subtracting the prevalence of smoking only oneself from the overall prevalence. The result is equivalent to exposure due to smoking of other persons, which was our definition of exposure. Exposure of children has been studied in Nordic countries (7). According to this study 7% of children were exposed weekly. We estimated the number of exposed children and young people (<15 years) assuming that 7% of the Finnish population under 15 years of age was exposed. The number of exposed elderly people (≥ 65 years) was based on data provided by the National Public Health Institute, in which 8.5% of respondents reported that their spouse smoked at home. This figure was applied to the Finnish population of that age.

To our knowledge, no measurement-based studies have been carried out on the concentration of nicotine in Finnish homes. Measurements in the homes of smokers in the United States have indicated mean levels of 1–6 μg/m³ (8, 9). The most recent measurements show lower levels than the older ones. We assumed that the mean level in Finland in January 2000 was 2 μg/m³. In order to make this figure comparable with those on occupational exposure, we multiplied it by 2. The rationale for using a multiplier is that the annual time spent at home is approximately three times as long as the time at work. On the other hand, a substantial part of time at home is spent sleeping and resting, both of which require a lower inhalation volume than working. Therefore, we gave the multiplier a value of 2 instead of 3, which resulted in a nicotine estimate of 4 μg/m³ for exposure at home (comparable with estimates of occupational exposure).

Other exposure

The predominant source of exposure to environmental tobacco smoke outside work and the home in January 2000 was smoking in bars, pubs, dance restaurants, night clubs, music clubs, and similar places. No information on the numbers of persons exposed during these leisure-time activities was available from Finnish surveys or studies. The exposure levels during exposure are likely to be close to those experienced by restaurant workers. The annual exposure is probably lower because the daily time spent in smoky restaurants is, on the average, shorter than worktime.

Because direct information on the numbers of exposed persons and their mean level of exposure was missing, we used an indirect method to infer the annual exposure of the Finnish population due to exposure in restaurants and other similar places. We estimated that the annual total dose (level × duration of exposure) of all restaurant customers was 10 times that of restaurant workers. This estimate was based on the assumption that, for each exposed restaurant worker, there was an average of 10 customers who were exposed to similar smoky air.

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Results

Numbers of exposed persons at work

Approximately 330 000–340 000 salaried workers were exposed to environmental tobacco smoke at work in 1997 according to figures calculated from data of Statistics Finland (table 1). This is about 18% of 1.85 million employees and 16% of 2.17 million employed workers (including self-employed and family workers) in 1997. We consider these figures to be reasonably valid estimates also for January 2000. (See the Material and Methods section.) The corresponding estimate in 1990 was over 600 000 exposed workers (32% of employees), indicating that the regulations restricting smoking at work in 1995 had decreased exposure significantly. The decrease was especially pronounced among those who were previously almost continually exposed.

Two-thirds (67%) of the exposed were men. However, the majority (57%) of those exposed nearly all the time was women. The prevalence of exposure was age-related so that, among both men and women, the younger age groups were more frequently exposed. The prevalence was 42% for young employed men (15–20 years) and 11% for older employed men (60–64 years). Among the women the prevalence decreased from 22% to 4% by age, respectively. The trends were the same for those who reported nearly continuous exposure: from 4% to 0% for the men and from 13% to 0% for the women. Exceptionally many of those continuously exposed were below 20 years of age (over 1000 men and nearly 5000 women).

The industry with the highest absolute number of exposed workers was construction (NACE Rev 1, 45), in which 38% of the workers (over 50 000) reported exposure. About half of the workers (over 38 000) in the hotel and restaurant sector (NACE Rev 1, 55) were exposed. The numbers of exposed persons were high also in the basic metal (8000), metalware (11 000), and machine (18 000) industries. Nearly continuous exposure to environmental tobacco smoke was the most common in the hotel and restaurant sector (16 000, 21% of the employed persons in that sector). A portion of workers continuously exposed in the retailing of gasoline and in water transport may also in fact have been "restaurant workers" (in cafés of gasoline stations or in restaurants and bars of ships and car ferries).

Restaurants, bars, and clubs usually employ less than 50 workers. Continuous exposure to environmental tobacco smoke occurred the most frequently in small restaurants (32% in restaurants of 5–10 workers), but it was also rather common in larger (21–25%, 10–50 workers) and very small (12%, 1–4 workers) restaurants. The largest workplaces (over 50 workers) in the hotel and restaurant sector were hotels with no continuous exposure. In sectors other than hotels and restaurants exposure was almost as prevalent (14–20%) in all size categories of workplaces. Continuous exposure was rare (1%) and occurred slightly more frequently in size classes 100–199 workers (3%), 1–4 workers (2%), and 500–999 workers (2%). These figures may be unstable due to small sample sizes, but they indicate that exposure to environmental tobacco smoke occurs in both small and large workplaces due to neglect of smoking regulations, or due to exposure in designated smoking areas.

According to the data from Statistics Finland, continuous exposure to environmental tobacco smoke was the most common in the occupations presented in table 2. The number of all exposed workers was highest in large occupational groups such as engineering and structural metal work (60 000), architectural and engineering work (25 000), building construction work (22 000), road transport work (20 000), and executive- and management-related work (19 000). The prevalence of exposure was highest in waitering (64%), engineering and structural metal work (45%), land and water construction (44%), public safety and protection (44%), steel mill and metallurgical work (43%), building construction (38%), machine operation in energy and water supply (38%), and laundry work (33%).

The largest groups reporting continuous exposure were waiters (9300), engineering and structural metal workers (4700), salespersons (3700), and executives and managers (excluding public administration) (2300). Over half of these workers were employed in occupations other than the hotel and restaurant sector. Continuous exposure was the most prevalent in waitering (39%), steel, metallurgical, forging and foundry work (29%), miscellaneous service work (eg, pursers, stewards, disc jockeys, guides) (10%), printing and photographic work (9%), and pulp and paper work (8%). With the exception of restaurant work, these figures are based on small numbers of respondents and therefore are unstable.

Table 1. Numbers of salaried workers occupationally exposed to environmental tobacco smoke in Finland in 1990 and 1997 (calculated on the basis of data from the questionnaire-based surveys of Statistics Finland).

	1990		1997	
	Salaried workers (%)	Exposed workers (N)	Salaried workers (%)	Exposed workers (N)
Exposed				
Nearly all of the time	4.5	95 000	1.6	30 000
About 75% of the time	1.1	23 000	0.5	9 000
Half of the time	2.6	55 000	0.9	17 000
About 25% of the time	5.4	114 000	2.0	37 000
Less than 25% of the time	18.2	385 000	13.2	244 000
Total	31.8	672 000	19.3	337 000
Unexposed	68.2	·	81.7	·

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Table 2. Estimated numbers of employed persons occupationally exposed to environmental tobacco smoke by occupation and duration of exposure in January 2000 in Finland.

Occupation [a]	Respondents [b] (N)	Employed (N)	Degree of exposure						
			Nearly all of the time	About 75% of the time	Half of the time	About 25% of the time	Less than 25% of the time	Not at all	Exposed (total N)
Waitering work (92)	41	23700	9300	1200	1200	1200	2300	8700	15100
Engineering and structural metal work (75)	173	134400	4700	3900	3900	12400	35800	73800	60600
Wholesaling and retailing work (34)	142	131300	3700	–	–	1800	7400	118300	12900
Enterprise and organizational leadership work (21)	86	101100	2300	2300	2300	–	11700	82300	18700
Steel, metallurgical, forging and foundry work (73)	7	6500	1900	–	–	900	–	3700	2800
Accommodation establishment and commercial and institutional household work (91)	82	66000	1600	800	–	1600	7300	54700	11200
Building and construction work (62)	74	57300	1500	–	2300	2300	15500	35600	21700
Printing and photographic work (80)	22	15000	1400	–	–	–	1400	12300	2700
Pulp and papermaking work (84)	24	14100	1200	–	–	–	1800	11200	2900
Secretarial and clerical work, etc (24)	215	117400	1100	600	600	1100	9300	104800	12600
Architectural and engineering work (00)	168	135500	800	–	800	1600	21800	110400	25100
Other service work (99)	10	7500	700	–	–	700	700	5200	2200
Building caretaking and cleaning work (94)	116	24600	700	–	700	–	2000	21300	3300
Electrical work (76)	76	57200	700	–	–	2200	9000	45100	12000
Road transport work (54)	97	70300	700	700	700	3700	14500	50000	20200
Other managerial, administrative and clerical work (29)	37	83100	700	700	700	1400	14300	65100	17900
Packing, wrapping, warehousing and stevedoring work (88)	70	42900	600	–	–	600	6700	34900	7900
Food and beverage manufacturing work (82)	37	19600	500	–	–	–	2100	16900	2600

[a] Code of the Finnish Occupational Classification in 1987 in parentheses.
[b] Number of respondents in the survey of Statistics Finland in 1997.

Exposure levels at work

One recent Finnish study on nicotine levels in the restaurant sector reported mean concentrations of 8–9 $\mu g/m^3$ (highest levels about 30 $\mu g/m^3$) in bars and restaurants and over 30 $\mu g/m^3$ (highest levels over 100 $\mu g/m^3$) in dance restaurants and night clubs (5). Bartenders and croupiers were exposed to higher concentrations than waiters on the average. Smoking has been prohibited at bar counters since March 2000 unless the ventilation arrangements are such that they prevent exposure of the bartender. Another Finnish study in the restaurant sector showed slightly different results (Johnsson et al, unpublished). The mean concentrations of nicotine were 2–3 $\mu g/m^3$ at static points and in breathing zones of workers in food restaurants. Personal samples averaged 10 $\mu g/m^3$ in bars and 18 $\mu g/m^3$ in dance restaurants and nightclubs. Using these data, we estimated 10 $\mu g/m^3$ to be representative of the mean level of nicotine in Finnish restaurants in January 2000.

Exposure levels outside the restaurant sector were studied before the 1995 smoking restrictions (6). A printing shop, machine shop, shipyard, and battery plant represented industrial workplaces. The service sector was represented by a transport company, a maintenance company, and an airport service. Office environment was studied in a police station and two government agencies. Smoking was allowed at that time in all of these workplaces, at least in certain areas. The mean nicotine concentration was about 3 $\mu g/m^3$ in industrial and service workplaces and below 1 $\mu g/m^3$ in office buildings. We took the value of 2 $\mu g/m^3$ to represent the concentration of nicotine in air during exposure for the exposed workers outside the hotel and restaurant sector.

Table 3 includes estimates of the level of occupational exposure in different subgroups of the hotel and restaurant sector and other sectors. The overall mean level of all occupationally exposed persons was about 1 $\mu g/m^3$. The values in table 3 are group means, which may hide large individual variations. The lowest personal mean exposures are probably below 0.1 $\mu g/m^3$ (occasional exposure to almost smokeless air) and the highest ones exceed 100 $\mu g/m^3$ (continuous exposure in very smoky restaurants, etc).

Exposure at home

The exposure of the adult population to environmental tobacco smoke has been estimated in table 4 on the basis of data from the National Public Health Institute in 1999 (2). The newest population statistics available were from the end of 1998. The Finnish population is relatively stable, and these figures are probably close to

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Table 3. Estimated numbers of persons exposed to environmental tobacco smoke by the estimated mean levels of exposure in January 2000 in Finland.

Exposed group	Exposed (N)	Annual mean level of exposure (nicotine in air, μg/m³) [a]
Restaurant workers	38 400	5.6
Exposed nearly all of the time [b]	16 400	9.0
Exposed about 75% of the time	4 600	7.5
Exposed half of the time	1 800	5.0
Exposed about 25% of the time	4 600	2.5
Exposed less than 25% of the time [b]	11 000	1.0
Other workers	298 600	0.4
Exposed nearly all of the time [b]	13 600	1.8
Exposed about 75% of the time	4 400	1.5
Exposed 45% of the time	15 200	1.0
Exposed about 25% of the time	33 400	0.5
Exposed less than 25% of the time [b]	233 000	0.2
All exposure at work	337 000	1
All exposure at home	570 000	4
All other exposure	>1 000 000	<2

[a] The level of exposure during exposure was assumed to be 10 μg/m³ in the hotel and restaurant sector and 2 μg/m³ in the other sectors; for exposure at home and other exposure, see the text.
[b] The duration of exposure was assumed to be 90% for the class "nearly all the time" and 10% for "less than 25% of the time".

Table 4. Estimated numbers of persons exposed to environmental tobacco smoke at home in January 2000 in Finland.

Group exposed at home	Population (million)	Exposed	
		N	%
Adults (15–64 years)	3.45	438 000	12.7
Him- or herself, spouse or other person smokes at home		904 000	26.2
Only him- or herself smokes at home		466 000	13.5
Children and adolescents (<15 years)	0.95	67 000	7
Elderly people (>64 years)	0.76	65 000	8.5
Total, Finnish population	5.16	570 000	11

those of January 2000. According to these estimates about 440 000 adults aged 15–64 years (13%) were exposed to environmental tobacco smoke. The adult population may be exposed both at home and at work. Additional exposure during visits in smoky restaurants and other leisure-time activities is also possible.

The number of children and adolescents under 15 years of age who are exposed to environmental tobacco smoke at home is 60 000–70 000, based on the prevalence figure of 7% from a Nordic study (7). Of this number, 20 000–30 000 are children under 5 years of age. Because somebody is smoking in 26% of Finnish homes, smoking in homes with children is rarer than in other households. Home is usually the only source of exposure among children. For young people approaching the age of 15 years, leisure-time activities (eg, smoking of friends) may also contribute to exposure.

About 60 000–70 000 senior citizens, over 65 years of age, were exposed to environmental tobacco smoke mainly due to smoking of their spouses. According to the survey of the National Public Health Institute in 1999, 8.5% of respondents had a spouse who smoked at home. The predominant source of exposure among senior citizens is home, but also friends, restaurant visits, and other leisure-time activities may contribute.

Because the levels of exposure to environmental tobacco smoke in smokers' homes have not been measured in Finland, we used measurements carried out in other countries to estimate that it would currently average 4 μg/m³ for nicotine in units which are comparable with the estimates of occupational exposure. (See the Material and Methods section). This figure can be compared with the occupational exposures listed in table 3. It corresponds approximately to the exposure of a restaurant worker who is daily exposed to environmental tobacco smoke for 3–4 hours. The variability of exposure and the highest exposures at homes are probably lower than in smoky restaurants because there is often only one smoker at home, but there may be tens of concurrent smokers in restaurants.

Other exposure

No direct data on the numbers of Finns exposed to environmental tobacco smoke outside work and home were available. Because it can be assumed that the predominant source of exposure is smoky restaurants, we estimated the total leisure-time dose of the Finnish population from the exposure figures of restaurant workers. According to table 3 the dose of all exposed restaurant workers during a workyear was approximately 38 400×5.6=215 000 μg/m³-workyear. The total dose estimate of all restaurant customers would be, on that basis, 2 150 000 μg/m³-workyear. (See the Material and Methods section.) The number of Finns who spend leisure time in restaurants at least occasionally is very large, probably over 1 million. The preceding dose estimate for restaurant customers would be compatible, for example, with 1 million persons exposed to a nicotine concentration of 2 μg/m³ or 2 million persons exposed to a concentration of 1 μg/m³ on the average. Individual variation between restaurant customers is probably large, ranging from less than 0.1 μg/m³ (occasional exposure to almost smokeless air) to over 20 μg/m³ (eg, over 8 hours/week in very smoky restaurants).

The environmental tobacco smoke dose of restaurant customers is significant when compared with exposure at work and at home. On the basis of table 3 the population dose of all Finns in January 2000 would be about 4 760 000 μg/m³-workyear. The share of occupational exposure would be about 337 000 μg/m³-workyear (7%), that of home exposure would be about 2 280 000 μg/m³-

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workyear (48%), and that of leisure-time (restaurant) exposure 2 150 000 µg/m³-workyear (45%).

Discussion

We consider the estimates of current occupational exposure to environmental tobacco smoke in Finland to be rather valid because comprehensive data were available both on numbers of workers exposed from questionnaire-based surveys and on exposure levels at work from three separate studies.

The exact form of the question in the interview survey corresponded well with our definition of exposure to environmental tobacco smoke and allowed also an estimation of the duration of exposure, which was necessary for the estimation of annual doses of exposed groups. In contrast to many other chemical exposures, environmental tobacco smoke is also an exposure that the respondents are likely to identify and report rather reliably. Another advantage is that the questionnaire-based surveys are designed to be representative and they provide prevalence figures that can be generalized to concern the population under study. For some subpopulations, however, figures may be less reliable because they are based on small numbers of respondents. Therefore the industry- and occupation-specific numbers should be considered with caution.

We estimated that a rather large proportion of employed persons were exposed to environmental tobacco smoke (16%, N=337 000), including a population of nearly continuously exposed workers (1.4%, N=30 000). Comparing these figures with estimates from other countries is difficult because the definitions, criteria of exposure, and years of the surveys vary. One comparative study within Nordic countries (10) reports that 30% of Danish, 20% of Norwegian, 19% of Swedish, and 14% of Finnish workers are exposed to environmental tobacco smoke at least one-fourth of the time. These figures are based on national questionnaire surveys in 1989 or 1990. The corresponding Finnish prevalence for January 2000 is 4%, indicating a clear improvement between 1990 and January 2000. The change is probably mainly due to the decrease in smoking in the 1990s and the legal restrictions enforced in 1995. Nordic data also indicate that the prevalence of smoking and smoking habits at work may exert an effect because, in 1990, there were very few regulations restricting smoking at work in the Nordic countries. Occupational exposure to environmental tobacco smoke (at least 75% of the time) in 1990–1993 was estimated also for the member states of the European Union (11). The number of these nearly continuously exposed workers was 7.5 million, which is 5% of employed workers. However, these figures may be biased because the estimation method was partly based on Finnish prevalence figures from 1990 and comparative national data were available only from a few other countries. The prevalence of exposure to environmental tobacco smoke among workers in the United States was 38% in 1988–1991 during the representative NHANES III survey (12).

The estimates on environmental tobacco smoke measured as nicotine concentrations were based on recent Finnish measurements in the restaurant sector and slightly older measurements in other sectors (5, 6 and Johnsson et al, unpublished). The samples of workplaces monitored were selected to be "typical", and their representativeness is unknown. There is no specific reason to believe that their results would be biased in either direction.

Nicotine has been widely measured in occupational settings in the United States, and there is a comprehensive recent review available (8). The results from three studies from the late 1980s and early 1990s (13–15) in the restaurant sector and office environment have been summarized (16). The mean levels weighted by the numbers of exposed persons were about 7 µg/m³ in restaurants and about 20 µg/m³ in bars. A more recent summary of two studies reported that waiters and waitresses were exposed to an average nicotine concentration of 6 µg/m³, and that for bartenders was 14 µg/m³ (17). High mean exposure has been measured among nightclub musicians, whose exposure often exceeds 30 µg/m³ (18). The mean value, which we used in the calculations in the restaurant sector (10 µg/m³), does not contradict these results.

The results of recent Finnish measurements on nicotine have been less than 1 µg/m³ in offices and 2–3 µg/m³ in industrial and service workplaces (6). The summary of three studies in the United States reports that the mean level in offices was 4 µg/m³ in the late 1980s and early 1990s (16). The results of studies in the industrial and service sector in the United States have provided very varying results, from low to high levels (8). The studies on exposure of railroad workers are representative, but many other studies may have been selective in sampling sites and conditions, which complicates comparisons. Our best estimate for exposure outside the restaurant sector (2 µg/m³) was based on recent measurements in Finland (6). It is lower than the mean level reported for North American offices (3), but the difference may rise from different degrees of smoking restrictions in the United States about 10 years ago and in Finland in January 2000.

Our estimates of exposure to environmental tobacco smoke in Finnish homes are probably less accurate than those for occupational exposure because fewer data on the prevalence of exposure and no Finnish measurements on levels of exposure were available. The form of the question on environmental tobacco smoke

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exposure at home in the postal survey we used did not directly correspond with our definition of exposure to environmental tobacco smoke. However, an estimate could be calculated from available data. (See the Material and Methods section.) Data did not provide any measure of the duration of exposure at home, which would have supported the estimation of exposure levels. In addition, it is unclear how respondents interpret "in your dwelling". It is possible that some respondents may also include smoking outdoors (eg, in the balcony or garden), and, if so, would lead to an overestimate of the prevalence. Our best estimate for the nicotine levels of smokers' homes was 2 $\mu g/m^3$, based entirely on measurements carried out mainly in the 1980s in North America (9, 19), where the reported mean levels were 1–6 $\mu g/m^3$. The lowest figure (1 $\mu g/m^3$) comes from the most recent study in California (9). We also used 2 as a multiplier to account for different time-activity patterns at home and work and to make figures mutually comparable. (See the Material and Methods section.)

The estimated prevalence of exposure to environmental tobacco smoke in Finnish homes in January 2000 was 11% of the population (N=570 000). The prevalence was higher for adults (13%) than for children (7%) and senior citizens (8%). The representative NHANES III survey in 1988–1991 reported that, in the United States, 21% of adults who work were exposed at home (12). This figure is higher than the Finnish estimate, which may be explained by different smoking prevalences during surveys in the United States and Finland. Children's exposure to environmental tobacco smoke originates mainly from home. According to a summary (19), the prevalences in studies in the United States in 1984–1991 have been 32–55%, which are substantially higher than the 7% used as the prevalence for Finnish children and adolescents (<15 years of age). The Finnish prevalence is based on a Nordic study (7).

Our estimates on the population dose due to customer exposure in restaurants are based on the corresponding dose of restaurant workers and an assumption that customers as a group inhale 10 times as much smoky air as restaurant workers as a group. The dose of the restaurant workers could be assessed with reasonable confidence with the use of comprehensive data on the prevalence and level of exposure to environmental tobacco smoke. The multiplier (10) is a crude estimate of the average number of customers per restaurant worker. So far there are no empirical data to back it up. Therefore the estimates of the customer dose and its share of the total dose of the Finnish population are less certain than the estimates for exposure at work and home. In addition, we did not even try to estimate other occasional exposures during leisure time on the assumption that they were minor as compared with exposure at work, at home, and in restaurants.

The question on the past prevalence and level of exposure to environmental tobacco smoke as compared with the current situation is important from the point of view of risk assessment. There is clear evidence in Finnish data that the prevalence of exposure at work was higher before 1995, when smoking restrictions came into effect at workplaces. According to table 1, the prevalence of exposure to environmental tobacco smoke at work in 1990 was 1.6 times that in 1997, and the prevalence of continuous exposure was 2.8 times as high. According to the survey of the National Public Health Institute, the prevalence of exposure to tobacco smoke (at least an hour a day) at work was 2.3-fold in 1989–1990 and 2.5-fold in 1983–1985 as compared with 1997 (2). When the situation of January 2000 is compared with that of the 1960s, the difference in the prevalence is probably still larger because exposure to environmental tobacco smoke decreased in 1997–2000 by about 15% and smoking in the 1960s was more common (about 35% of the Finnish population smoked daily) than in 1997 (24% smoked daily) (2, 20). The level of exposure may also have been higher, but there is no empirical evidence of that from Finland.

Exposure to environmental tobacco smoke in the homes of smokers was also more prevalent in the past than currently, but the decrease over time has been smaller than at work. The results of the survey of the National Public Health Institute suggest that exposure to tobacco smoke at home in 1989–1990 was 1.2 times as prevalent as in 1997. In comparison with 1983–1985 (earliest data available), the difference was 1.3-fold (2). Before 1983 the prevalence was probably still somewhat higher due to the higher smoking rate of Finns in the 1960s and 1970s. There are no measurement data available on past or current exposure levels in Finnish homes.

The temporal change of exposure to environmental tobacco smoke during leisure time is also likely to be smaller than at work. The number of restaurant customers and restaurant visits has probably increased as incomes have improved and leisure time has become more available. On the other hand, the level of exposure may have decreased because, in the past, a larger proportion of customers were smokers and the ventilation of restaurants was less effective than today.

The new smoking restrictions concerning the restaurant sector since March 2000 and July 2001 are expected to decrease the exposure of restaurant workers and customers even further. Suggestive evidence of improvement of the situation in restaurants comes from the latest survey of the Finnish Institute of Occupational Health (interviews in January–May 2000), according to which the prevalence of exposure had decreased from 47% in 1997 to 41% in 2000 among respondents employed in the hotel and restaurant sector. The proportion

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of those experiencing rather or very much inconvenience due to environmental tobacco smoke also dropped from 18% to 12% (3).

Although the prevalence of exposure to environmental tobacco smoke has decreased due to legal restrictions on smoking, it is still probably the most frequent occupational exposure to a chemical carcinogen. When occupational exposure to carcinogens in the European Union was estimated for 1990–1993, environmental tobacco smoke was second only to ultraviolet radiation (solar light) (11). About 5% of the employed population was estimated to have been exposed at least 75% of the worktime. Environmental tobacco smoke was more common at workplaces than silica, diesel exhaust, radon, and wood dust, for example. The variation in the prevalence across countries is probably considerable due to differences in smoking habits and legal restrictions. According to the Eurobarometer Survey (21), the prevalence of daily smokers in the member states of the European Union was 20–39% in 1995. The highest prevalences were found in Greece (39%), Denmark (38%) and Italy (38%), and the lowest in Portugal (24%), Sweden (22%) and Finland (20%).

The strength of our approach is that it joins the prevalence and the corresponding level of exposure and thus allows a direct application of quantitative risk models, such as that by Repace and his co-workers (4). One of the basic difficulties in the risk assessment of environmental tobacco smoke is the application of epidemiologic risk estimates reflecting past exposure to current exposures, whose future effect is to be assessed. This comparison is complicated due to the lack of past exposure data and thus a potential source of large errors. The weakness of our approach is mainly the assumptions we had to make to estimate exposures at home and during leisure time. This uncertainty is carried over to estimates of cases attributable to environmental tobacco smoke, whose accuracy depends also on the validity of the risk model adopted.

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Prevalence of exposure to environmental tobacco smoke at work and at home — 15-year trends in Finland

by Pekka Jousilahti, MD,[1,2] Satu Helakorpi, MSc [2]

Jousilahti P, Helakorpi S. Prevalence of exposure to environmental tobacco smoke at work and at home — 15-year trends in Finland. *Scand J Work Environ Health* 2002;28 suppl 2:16–20.

Objectives This study describes the 15-year trends of exposure to environmental tobacco smoke at work and at home in Finland.

Methods A postal survey was made annually from 1985 to 2000. It included a random sample of 58 721 Finnish men and women aged 15 to 64 years.

Results In the middle of the 1980s, about a quarter of employed nonsmoking men and 15% of nonsmoking women were exposed at least 1 hour daily to environmental tobacco smoke at work. In 2000, the proportions were 7.9% and 4.4%, respectively. Exposure to environmental tobacco smoke at home decreased also slightly. In 2000, 14.3% of the nonsmoking men and 13% of the nonsmoking women aged 15 to 64 years were exposed to environmental tobacco smoke either at work or at home. Exposure at work was about three times more common among smokers than among nonsmokers, but a decreasing trend was also found among smokers. In 2000, in 85% of workplaces smoking was permitted only in separate smoking rooms, or no one was smoking within the work environment. On the other hand, in 7.3% of workplaces smoking was permitted also in common areas.

Conclusions In the past 15 years, exposure to environmental tobacco smoke at work decreased significantly in Finland. Both legislative actions and the general decrease in smoking prevalence have contributed to this decline. However, despite the marked decrease, nearly 14% of nonsmokers aged 15 to 64 years are still exposed to environmental tobacco smoke, either at home or in the workplace.

Key terms legislation, passive smoking, prevalence, smoking, tobacco, workplace.

Disease risk due to smoking is not limited to smokers only. Passive smoking, or exposure to environmental tobacco smoke, is linked with adverse health effects, and it increases the risk of several diseases, such as cardiovascular disease, lung cancer, other respiratory diseases, and low birthweight (1–11).

Environmental tobacco smoke originates from the smoldering of a cigarette or other tobacco product. The smoke dilutes in the ambient air and diffuses and spreads through it. The composition of the smoke inhaled by a smoker, generally referred to as mainstream smoke, differs from the smoke inhaled by others, generally referred to as the sidestream smoke (12). Sidestream smoke may be even more harmful for health than mainstream smoke (13, 14). In addition to nonsmokers, also smokers themselves are exposed to environmental tobacco smoke.

Even though many countries have restricted smoking in workplaces, millions of people are still exposed to environmental tobacco smoke at work. Even more nonsmoking people, especially women and children, breathe tobacco smoke at home (10, 11). During leisure time, at least occasional exposure to environmental tobacco smoke is also common, particularly in bars and restaurants.

In this paper we present the 15-year trends of exposure to environmental tobacco smoke at work and at home in Finland. In addition, changes in smoking arrangements in workplaces during the past 5 years are presented.

1 University of Helsinki, Department of Public Health, Helsinki, Finland.
2 National Public Health Institute, Department of Epidemiology and Health Promotion, Helsinki, Finland.

Reprint requests to: Professor Pekka Jousilahti, University of Helsinki, Department of Public Health, PO Box 41, FIN-00014 University of Helsinki, Helsinki, Finland. [E-mail: pekka.jousilahti@ktl.fi]

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Materials and methods

The National Public Health Institute has annually conducted the Adult Health Behavior Survey in Finland since 1978. The primary purpose of the survey is to obtain information on health behavior such as smoking and changes in it. Every year a self-administered postal questionnaire has been sent to a random sample of the Finnish population aged 15 to 64 years. Questions related to exposure to environmental tobacco smoke at work and home were included in the survey in 1985. The sample sizes and participation rates are given in table 1. Since 1985, 27 496 men and 31 225 women have participated in the surveys. Of them, 27 382 (99.6%) men and 31 107 (99.6%) women had complete data on environmental tobacco smoke at home. Complete data for work was available for 22 320 (97.7%) men and 23 595 (98.3%) women who worked outside the home.

To assess the exposure to environmental tobacco smoke at work, the participants were asked how many hours during a workday they stayed in rooms where tobacco smoke was in the air. Among the smokers, the smoke in the workplace could have been generated also by the smoker him- or herself. From 1995 on, a question about smoking arrangements at the workplace was also included. The participants who did not work outside the home were excluded from this analysis. Exposure at home was assessed by asking whether somebody smoked at home. From 1998 on, the question was formulated in more detail, asking also the relation of the smoker to the respondent. Active smoking was assessed using a set of structured questions. On the basis of the responses, the participants were classified as daily smokers, occasional smokers, and nonsmokers. In this study, exposure to environmental tobacco smoke has been presented separately for nonsmokers and daily smokers. About 7% of the participants were occasional smokers. Generally, their exposure to environmental tobacco smoke was lower than that of daily smokers but higher than that of nonsmokers. However, because the number of occasional smokers was fairly small each year, occasional smokers were excluded from the analyses. Log-linear models were used to test the significance of the trends.

Results

Total exposure to environmental tobacco smoke at work decreased markedly in Finland in the 15-year period (figure 1). In 1985, 38.7% of the employed men and 22.4% of the employed women were exposed to environmental tobacco smoke. In 2000, the figures were 15% and 6.4%, respectively.

When the data were analyzed by the smoking status of the respondent, in 1985, about a quarter of the nonsmoking men and 15% of the nonsmoking women who worked outside the home were exposed to environmental tobacco smoke at work at least 1 hour daily (figure 2). In 1994, the proportions were 14.4% and 7.1%, respectively. A marked drop was seen in 1995, and a decreasing trend continued also thereafter. In 2000, 7.9%

Table 1. Sample sizes and participation rates in the Adult Health Behaviour Survey in Finland in 1985–2000.

Year	Men		Women		Total	
	N	%	N	%	N	%
1985	1637	65	1781	72	3418	68
1986	1902	78	2187	85	4089	82
1987	1873	76	2170	85	4043	81
1988	1884	74	2001	82	3885	78
1989	1853	73	2024	82	3877	78
1990	1811	73	2001	80	3812	76
1991	1783	72	2026	81	3809	76
1992	1733	69	1981	80	3714	74
1993	1610	64	1863	75	3473	69
1994	1669	66	1831	75	3500	70
1995	1688	67	1956	79	3644	73
1996	1669	66	1928	78	3597	72
1997	1586	64	1928	76	3516	70
1998	1689	66	1816	82	3505	70
1999	1538	60	1833	75	3371	68
2000	1569	64	1899	75	3468	70
Total	27 496	68	31 225	79	58 721	73

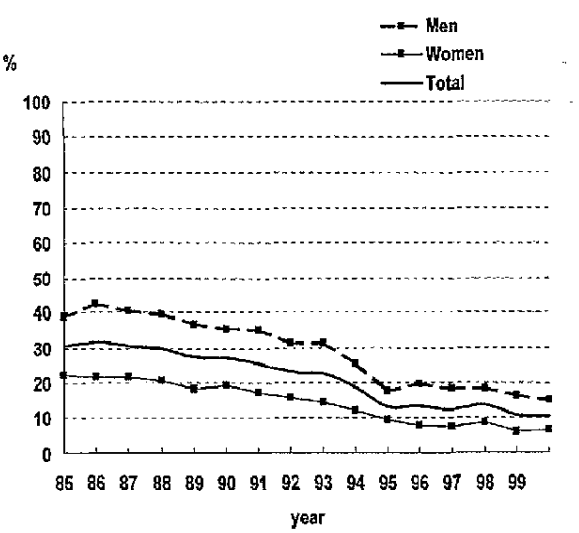

Figure 1. Proportion of persons exposed to environmental tobacco smoke at work for at least 1 hour daily in Finland in 1985–2000 by gender. (log-linear models: year: men P<0.001, women P<0.001, total P<0.001; gender: P<0.001; year × gender: P=0.292)

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of the nonsmoking men and 4.4% of the nonsmoking women reported daily exposure to environmental tobacco smoke at work. Among the smoking men and women exposure was markedly, about three times, more common than among the nonsmoking men and women.

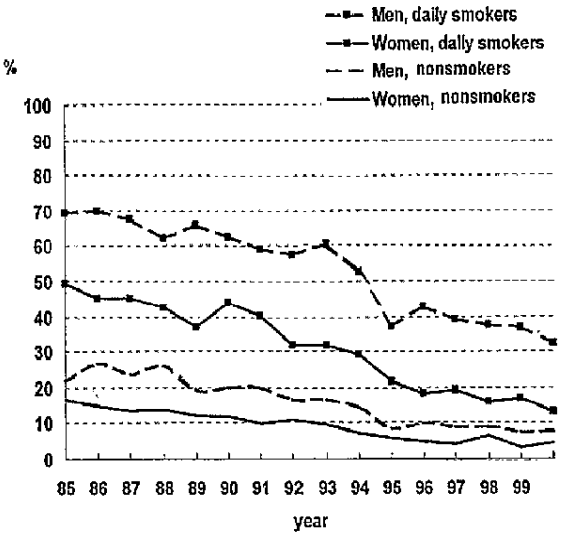

Figure 2. Proportion of persons exposed to environmental tobacco smoke at work for at least 1 hour daily in Finland in 1985–2000 by smoking status and gender. (log-linear models: year: nonsmoking men P<0.001, nonsmoking women P<0.001, smoking men P<0.001, smoking women P<0.001; gender: nonsmokers P<0.001, smokers P<0.001; year × gender: nonsmokers P=0.468, smokers P=0.206)

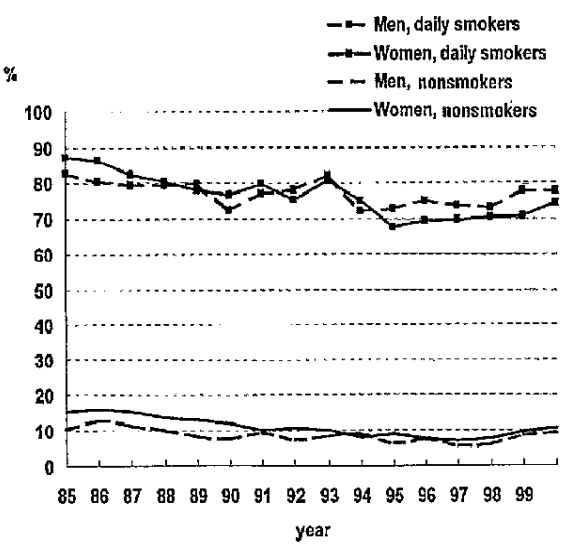

Figure 3. Proportion of persons exposed to environmental tobacco smoke at home in Finland in 1985–2000 by smoking status and gender. (log-linear models: year: nonsmoking men P<0.001, nonsmoking women P<0.001, smoking men P<0.001, smoking women P<0.001; gender: nonsmokers P<0.001, smokers P=0.607; year × gender: nonsmokers P=0.097, smokers P<0.001)

However, also among the smokers a decreasing trend was found. In 1985, 70% of the smoking men and 50% of the smoking women were exposed also to environmental tobacco smoke at work. In 2000, the proportions were 32.4% and 13.2%, respectively.

In the middle of the 1980s, about 11% of the nonsmoking men and 15% of the nonsmoking women were living in the same household with a smoker who smoked also at home (figure 3). A decreasing trend was seen until 1997, when the proportions were 5.8% and 7.1%, respectively. A mild increase was observed in the late 1990s, which, however, may have at least partly been due to small changes in the survey questionnaire.

At the beginning of the study period, over a quarter of the nonsmoking men and over 20% of the nonsmoking women were exposed to environmental tobacco smoke either at the workplace or at home or at both places (figure 4). In 2000, the proportions were 14.3% for the men and 13.0% for the women. Even lower exposure prevalences were recorded in the late 1990s.

In 1995, when a major change in tobacco legislation was introduced, 36% of the participants who worked outside the home reported that no one smoked in their workplace (figure 5). Smoking was permitted in separate smoking rooms in 45% of the workplaces. In 12.4% of the workplaces smoking was permitted also in private rooms, and in 6.8% it was permitted elsewhere than in smoking and private rooms. Between 1995 and 2000 the proportion of workplaces where smoking was allowed only in a separate smoking room increased to

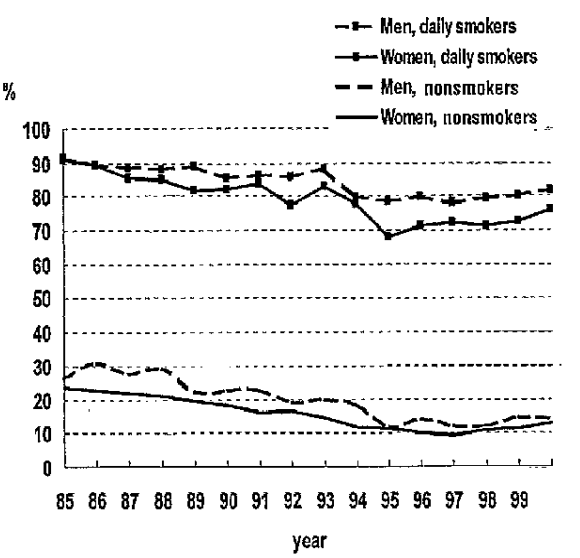

Figure 4. Proportion of persons exposed to environmental tobacco smoke at work or at home in Finland in 1985–2000 by smoking status and gender. (log-linear models: year: nonsmoking men P<0.001, nonsmoking women P<0.001, smoking men P<0.001, smoking women P<0.001; gender: nonsmokers P<0.001, smokers P<0.001; year × gender: nonsmokers P=0.107, smokers P=0.191)

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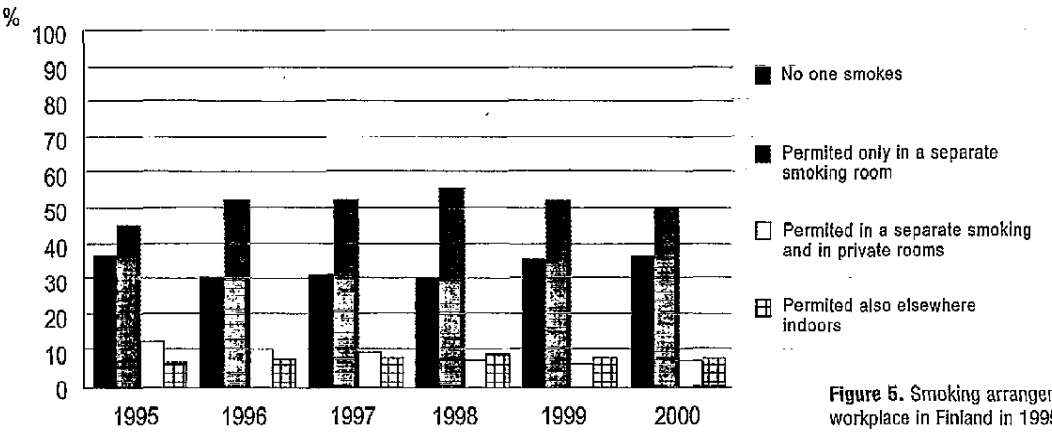

Figure 5. Smoking arrangements in the workplace in Finland in 1995–2000.

50%, and the proportion of workplaces where smoking was permitted also in private rooms decreased to 6.6%. However, the proportion of workplaces where smoking was permitted also elsewhere did not change markedly between 1995 and 2000.

Discussion

During the 15-year period of this study, exposure to environmental tobacco smoke decreased markedly in Finland. Among nonsmokers, the exposure at work decreased to one-third between 1985 and 2000. Exposure at work was about three times more common among smokers than among nonsmokers, but a decreasing trend was seen also among them. Exposure at home decreased only slightly. In 2000, about 14% of the nonsmoking men and 13% of the nonsmoking women were still exposed to environmental tobacco smoke either at the workplace or at home, or at both places.

Both the generally decreasing smoking prevalence and legislative actions have contributed to the observed decrease in exposure to environmental tobacco smoke. Since the 1960s, the smoking prevalence of Finnish men has decreased by half, from about 60% to about 30% (15). A drastic decrease was observed already in the 1960s and 1970s, but a slower decrease has continued also since then. However, during the same time period, smoking among women increased somewhat. In our sample, 31.9% of the men and 14.3% of the women were daily smokers in 1985 as compared with 27.3% and 20.3% in 2000.

The Tobacco Control Act of 1976 created a basis for a smoke-free environment in Finland. The act prohibited smoking in most public places and public transportation vehicles [Act on Measures to Reduce Tobacco Smoking (English translation of the Finnish tobacco act); see www.tupakka.org]. However, the act did not cover workplaces and restaurants. In 1994 the act was amended to include workplaces as well. In 2000, it was expanded further to include also restaurants. In 2001, at least half of the area of a restaurant should be completely smoke-free.

In 2000, no one was smoking inside in one-third of workplaces, in half of the workplaces smoking was permitted only in a separate smoking room, and in 7% it was also permitted in private rooms. However, in 7.3% of the workplaces, smoking was permitted also in common areas. In Finland, smoking in common work areas has been legally permitted in bars and restaurants, where the first smoking restrictions were introduced by law only in 2000. In addition to bars and restaurants, workers are exposed to environmental tobacco smoke also in a small proportion of other workplaces, in which smoking in common areas has been prohibited since 1995. These workplaces are usually small companies with 2–10 workers (16).

Recent results of the European Community Respiratory Health Survey show a very large variation between countries with respect to exposure to environmental tobacco smoke at work (11). The exposure was the most common in southern Europe. In Spain and Italy, 30% to 50% of workers are exposed to environmental tobacco smoke in their workplaces. Low exposure rates, 2.5% to 10%, were found in Sweden, New Zealand, Australia, and the United States. Thus our results show that, in comparison to circumstances at the international level, exposure to environmental tobacco smoke at work in Finland is relatively rare.

In conclusion, exposure to environmental tobacco smoke, particularly at work, decreased markedly in Finland between 1985 and 2000. Both legislative actions and the general decrease in smoking prevalence have

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contributed to this decrease. However, in 2000 over 14% of nonsmoking men and 13% of nonsmoking women were still exposed to environmental tobacco smoke either at work or at home.

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